update:
HED science instrument

European XFEL Users’ Meeting
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Thomas Tschentscher for HED
thomas.tschentscher@xfel.eu
Scope of this talk

- Overview
- Detailed experiment requirements
- Next steps
Ultrafast dynamics and structural properties of matter at extreme states

- Highly excited solids → laser processing, dynamic compression, high B-field
- Near-solid density plasmas → WDM, HDM, rel. laser-matter interaction
- Quantum states of matter → high field QED

Samples generated by pulsed excitation

- Highly dynamic and often non-equilibrium
- Irreversible processes → sample refreshment required

Combination of high excitation with various x-ray techniques

- Use of various pump sources to excite samples (OL, XFEL, ext. fields)
**A generic experiment at HED**

**X-ray in**
- Mostly probe beam
- Parameter definition
- X-rays delivery system

**Sample**
- Typically: Solid
- Fast exchange
- Fabrication

**Optical laser**
- Principal pump
- Several systems
- Pulsed magnets

**XRD / x-ray out**
- Structural probes
- Spectrometers
- Detectors
Completed, reviewed and published Conceptual Design Report (CDR)
- Reported at last UM
- XFEL.EU TR-2013-003; see www.xfel.eu/publications/internal-reports

Prepared Experiment Hall infrastructure requirements
- Room definition (scope & sizes)
- Infrastructure requirements (media, AC, power)

Launched civil construction of HED bits
- Laser tunnel (early construction with other tunnels surrounding Exp. Hall)
- HED-EXP using heavy concrete (early construction due to weight)

Started to define ‘standard’ x-ray beam delivery units (→IKC)

Distributed & evaluated questionnaire *Detailed Experiment Requirements*
HED optics hutch
Operation modes

HED experiment hutch

Interaction chamber
High pulsed magnetic field setup
SAXS/imaging detector setup
Beam stop assembly

PP-UHI
Chirp
Zeo, 3ø
UHI
HE
VISAR

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Operation modes

HED-EXP enclosure

Nov 2013  Technical specifications
Dec 2013  Call for tender
Jan 2014  Award contract
Jun 2014  Completion (concrete & door)

<table>
<thead>
<tr>
<th>Wall</th>
<th>Description</th>
<th>Wall thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>East</td>
<td>Entrance for x-ray FEL, entrance for PP-OL beams</td>
<td>0.8 m, heavy iron based concrete</td>
</tr>
<tr>
<td>North</td>
<td>Principle laser pointing direction; distance to IA point ~4 m</td>
<td>1.0 m, heavy iron based concrete</td>
</tr>
<tr>
<td>West</td>
<td>Secondary principle laser pointing direction; distance to IA point ~6-8 m</td>
<td>0.8 m, heavy iron based concrete</td>
</tr>
<tr>
<td>South</td>
<td>Access door; opposite to principle laser pointing direction</td>
<td>0.5 m, heavy iron based concrete</td>
</tr>
<tr>
<td>Roof</td>
<td>Access door; entrance for UHI- and HE-OL beams; height 2.6 m above IA point</td>
<td>0.88 m, normal concrete</td>
</tr>
</tbody>
</table>
Refined list of requirements for HED science applications

- X-ray beam parameters
- Optical laser parameters
- Detectors & spectrometers
- Sample preparation & insertion
- Details about procedures

Expert users (~10)

- Correspondents for certain type of HED application

Observations

- MEC experiments are very valuable experience
Dynamic compression

Imaging density modulations

Inelastic scattering

X-ray absorption spectroscopy

D. Milathianaki et al., Science 342, 220 (2013)

A. Schropp et al., Scientific Reports 3, 1633 (2013)

G. Monaco et al., under publication

F. Dorchies, J. Gaudin, A. Ravassio, M. Harmand, et al., under publication
Operation modes

Some details about experiments at HED

X-ray in
- 3 – 25 keV
- $10^{-5} – 10^{-1}$ bw
- <1 – 200 µm
- p.o.d – 4.5 MHz

Sample
- disruptive: 2D & fast exchange
- exactness/availability/debris
- repetitive: 3D

Optical laser
- 30 fs – 10 ns / chirp
- 10 µJ – (>1)100 J
- flexible geometry

XRD / x-ray out
- XRD/SAXS/imaging → area detectors
- IXS/XAS/XES → spectrometers
- specials

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Next steps

Technical Design Report (TDR)
- HED Users Workshop (tomorrow Thu, Jan 30, 14 – 18:30 hrs, FLASH)
  - Recent new developments
  - Discussion of HED layout & concept (TDR) with users
- Meeting of the HED Advisory & Review Team (HED-ART) (Mar 19)
  - Review TDR
- Publish TDR (end of April/early May)

Start construction
- Construction HED-EXP enclosure in June 2014
- Contracting other hutches and infrastructure before end 2014
- Construction of hutches & infrastructure completed in summer 2016

- Contracting x-ray and OL components starts now
- First x-ray beam in April 2017
HIBEF deliverables
- UHI- and HE-OL laser systems, incl. diagnostics, compressor, …
- Pulsed magnet setup
- X-ray spectrometers, detectors, …
- External laser building

Status
- OL definitions and interfaces have been discussed in detail
- Other contribution will be defined next
- Agreement between user consortium and European XFEL will be concluded
- First funds are expected to become available during 2014

Prospect
- HIBEF team at European XFEL will build up
Proposal by RAL to contribute nanosecond laser to HIBEF / HED

- DIPOLE: diode pumped ns laser (ceramic: YAG)
  - >100 J pulse energies
  - 10 Hz repetition rate
  - Pulse shape configurable

Proposal currently under evaluation
Laser tunnel connecting to (future) laser bldg

Scope
- Enable to bring large lasers to HED
- Installation in external laser bldg (to be build)
- Beam transport through tunnel to experiment hall
- Connect to MJ power supply for pulsed magnetic fields
- 2 x 2 m² cross-section
Multilayer based 8 mirror split & delay

- External contribution by U Münster funded through BMBF VF
- Installation inside x-ray beam transport for HED (WP-73)
- Delays of \(~2\) ps (20 keV) to \(~36\) ps (4 keV);
- Delaying 3\(^{rd}\) harm vs. 1\(^{st}\) harm.

BMBF project 05K10PM2
Time to 1st x-ray beam is ~3 years

- Rooms and infrastructure will be completed 2016
- X-ray delivery systems will be available 2016
- Optical lasers system will be available before start of x-ray beam
  - Biggest challenge: HE-OL
  
⇒ HED instrument will be available in time for first x-rays

HED science portfolio

- Method & instrument development on-going
  - Dynamic compression using OLs
  - High resolution x-ray scattering
  - (Coherent) imaging techniques

- Science applications still exploring new capabilities
  - Pulse high magnetic fields
  - Materials science applications
  - High field QED applications
The HED team plus

- Motoaki Nakatsutsumi
- Karen Appel
- Ian Thorpe
- Thomas Tschentscher (interim)
- Alexander Pelka (HZDR)
- Bruno Mueller (LULI)

Laser group
Gerd Priebe, Guido Palmer & Max Lederer

CIE team
Lewis Batchelor & Antonios Lalechos

Sample environment group
Joachim Schulz & Carsten Deiter

+ Photon diagnostics, Detector, DAQ/Ctrl groups

XROBT group
Harald Sinn & Martin Dommach